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R&S® FSUP

Signal Source Analyzer

Phase noise tester, high-end spectrum and signal analyzer in a single box



75 Years of
Driving
Innovation



ROHDE & SCHWARZ

R&S®FSUP Signal Source Analyzer

At a glance

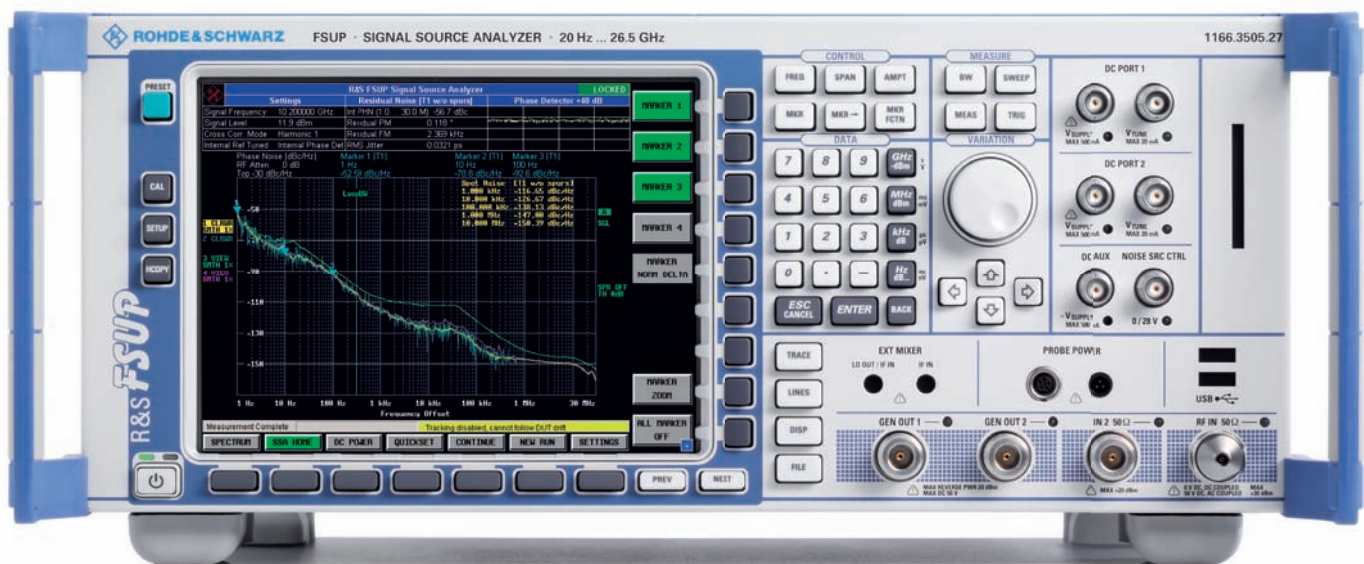
The R&S®FSUP combines the functionality of a high-end spectrum and signal analyzer with the advantages of a pure phase noise tester. The instrument is a unique and easy-to-use single-box solution for measuring oscillators and synthesizers in development and production applications. In addition, it leads to enormous cost reductions.

One of the primary tasks in developing transmit and receive modules is to measure oscillator phase noise. This is necessary not only in the development and production of state-of-the-art communications and broadcast systems, but also in special high-tech applications such as radar. Apart from phase noise, other parameters that need to be measured when characterizing oscillators include tuning slope, transient response, power, harmonics and spurious emissions. Amplifier noise is of significant interest as well. All of these measurements can be carried out with the R&S®FSUP, the only signal source analyzer that covers the frequencies up to the microwave range in a single box. The R&S®FSUP also features very-low-noise DC sources to enable a wide range of measurements.

The unique combination of a phase noise tester with low-noise DC sources and a spectrum and signal analyzer in a single box enables simple, cost-optimized test setups for development and production.

Key facts

- Frequency range up to 8/26.5/50 GHz
- Up to 110 GHz with external mixers
- Low-noise DC outputs for supply and tuning voltages
- Maximum flexibility for phase noise measurements
- Noise figure and gain measurements
- Oscillator characterization
- Analysis of digital and analog modulated signals



R&S®FSUP Signal Source Analyzer

Key features and benefits

Highly flexible phase noise tester with versatile measurement capabilities

- Phase detector method with internal/external reference
- Two-DUT method
- High sensitivity
- Automatic setting of all important parameters
- Easy operation
- Detection, suppression and listing of interference
- Measurement of reference points as a function of frequency
- Measurement of residual phase noise
- AM noise

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Maximum dynamic range through cross-correlation

- Sensitivity improved by up to 20 dB
- Cross-correlation up to 50 GHz in a single box

▷ [page 7](#)

Unique combination of phase noise tester and spectrum analyzer

- Measurement of phase noise using the spectrum analyzer method
- Typical spectrum measurements such as ACP or interference search
- Measurement of noise figure using the R&S®FSUP

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Analysis in the time domain

- Transient response of oscillators

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Characteristics at the push of a button

- Low-noise voltage source for supply and tuning voltages
- Complete characterization of oscillators

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Analysis of digital and analog modulated signals

- General vector signal analysis of digitally modulated signals
- Special analysis options for digital communications standards
- Analysis of analog modulated signals (AM/FM/φM)

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Highly flexible phase noise tester with versatile measurement capabilities

Phase detector method with internal/external reference

In this mode, the R&S®FSUP offers various settings for phase noise measurements. The most commonly used mode – measurement by means of an internal phase comparator using an internal reference – is predefined. Since many applications call for an extended test setup, the R&S®FSUP provides a straightforward menu for easily setting various measurement modes.

Two-DUT method

When using high-grade oscillators with very good phase noise characteristics, the oscillators are commonly measured against one another and the result is corrected by 3 dB – a measurement that can be carried out directly by means of the R&S®FSUP. Even if the application requires a complex test setup, such as using an external reference and external downconverter, such tasks are easy to accomplish with the R&S®FSUP because the user is supported through graphical tools.

Exceptional sensitivity

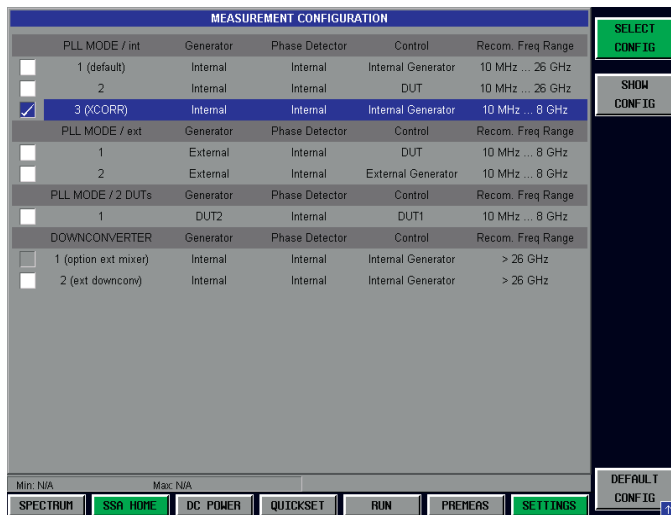
To ensure reliable oscillator measurements, the internal reference must exhibit negligible phase noise compared to the oscillator. For this purpose, the R&S®FSUP has an internal source with exceptionally low phase noise values, e.g. at an input frequency of 1 GHz with cross-correlation:

- -143 dBc (1 Hz) at 10 kHz frequency offset
- -172 dBc (1 Hz) at 10 MHz frequency offset

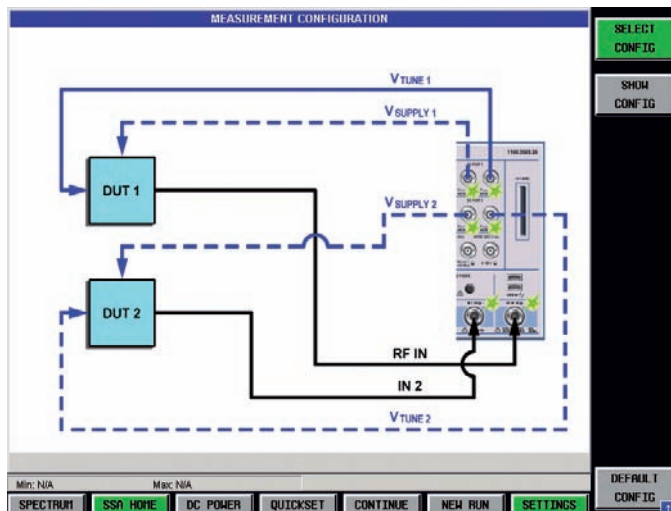
Automatic setting of all important parameters

All important oscillator parameters, such as power and tuning slope, are automatically measured in order to generate stable settings for the PLL loop. In addition, the loop bandwidth and IF gain are set automatically. All of the automatically set parameters can be modified and adapted to specific measurement tasks. The R&S®FSUP thus offers a solution for experts with special requirements, as well as for users who want to obtain measurement results quickly and easily.

Easy setting of test setup in configuration menu with display of recommended measurement range.



Measurement carried out on two identical oscillators. The final result is corrected by 3 dB.

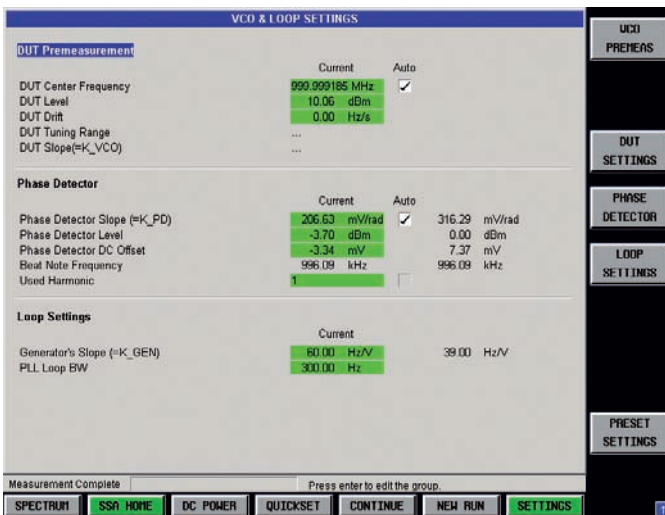


Easy operation

Straightforward menus make it easy to perform all other settings and adapt them to the user's requirements. Together with other measurement parameters such as bandwidth, filter type and number of averages, the offset frequency range for the phase noise measurement, for example, is conveniently configured by means of a straightforward menu. The menu layout is similar to that of the R&S®FS-K40 spectrum analyzer application firmware for phase noise measurements. This makes operation very easy, especially when switching between the various measurement modes. Predefined settings for fast or highly accurate measurements simplify operation even more.

After starting the phase noise measurement, LOCKED or UNLOCKED is displayed to indicate if the PLL is locked and whether a successful measurement can be started. The display shows the loop bandwidth used and the phase detector voltage during the measurement. In addition, limit lines can be activated. Integral parameters such as residual FM/φM or RMS jitter are displayed. The complete measurement range is used to perform the calculation. The integration limits are also user-definable.

Listing of all important parameters for a stable phase noise measurement using the phase detector method.



Typical phase noise measurement with the phase detector method: Signal frequency, level and residual FM/φM are displayed.



Detection, suppression and listing of interference

Interference caused by AC hum or other sources in the test setup commonly occurs during phase noise measurements. The R&S®FSUP features the option of listing and suppressing all interference, or only clearly defined interference.

Instead of imaging the frequency response of the resolution filter being used for the phase noise measurement, interference can also be displayed in dBc by activating the "highlight spurs" function. This provides a clear and simple way to identify interference.

The interference level is output in either dBc or dBc (1 Hz). This also enables the definition of limit lines that not only represent a threshold for the maximum allowable phase noise, but especially apply to spurious emissions. For a VCO test for instance, the user can decide whether to check phase noise, spurious emissions or both.

Measurement of reference points as a function of frequency

For many applications, especially in the production of oscillators, phase noise is of interest only for certain offset frequencies (reference points referred to as spot noise) because these values are included in the data sheet. Furthermore, it is important to measure the phase noise over the entire tuning range of the oscillator at these reference points. Using the SPOT NOISE vs TUNING function, the R&S®FSUP performs exactly this measurement and makes it possible to measure all phase noise values that are listed in the oscillator data sheet at the push of a button.

The benefits are as follows:

- ▀ Substantially simpler programming for production applications
- ▀ Higher measurement speed

Measurement of residual phase noise

With RF transmitters, the oscillator is not the sole source of phase noise. Particularly in high-end applications, it is helpful to know which other components such as amplifiers and frequency dividers contribute to phase noise. The R&S®FSUP has the flexibility to carry out these complex measurements as well. The measurement can be performed by using an internal or an external phase shifter. The R&S®FSUP software guides the user through a wizard-like function to complete the calibration.

AM noise

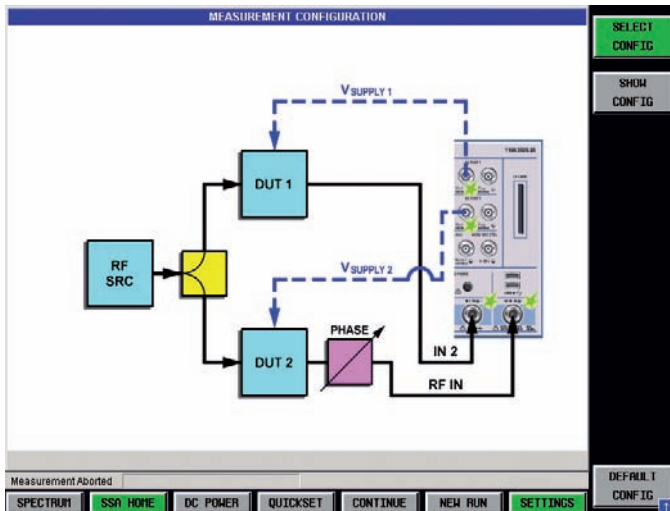
Phase noise measurements with a spectrum analyzer always represent the sum of phase noise and amplitude noise. The phase detector method suppresses the amplitude noise. The amplitude noise can also be measured with the R&S®FSUP by means of an external diode.

Phase noise values of an oscillator at different offset frequencies as a function of tuning voltage.



Typical test setup for residual noise measurements.

Through a 90° phase shift of the paths, inherent generator noise is eliminated, leaving only the noise caused by the DUT.



Maximum dynamic range through cross-correlation

Dynamic range increased by up to 20 dB at 26 GHz

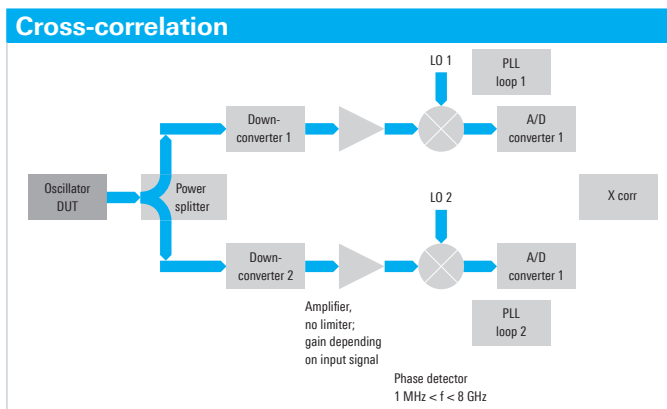
Cross-correlation significantly increases the dynamic range, which is no longer limited by the phase noise of the internal references. The degree of improvement, which can be up to 20 dB, depends on the number of averages. The R&S®FSUP thus enables users to measure phase noise in the microwave range. Previously, such tests were possible only with very expensive low-noise signal sources and required complex setups.

High-end measurements in this range can now be carried out at the push of a button with a single instrument.

Cross-correlation up to 50 GHz in a single box

The R&S®FSUP-B60 and R&S®FSUP-B61 options expand the R&S®FSUP with two parallel receiver paths up to 50 GHz. The symmetrical structure enables cross-correlation to be carried out between the two paths, eliminating the uncorrelated inherent noise of the two reference sources. This method can be used with the R&S®FSUP-B60 option in the frequency range from 1 MHz to 8 GHz (all R&S®FSUP models) and with the R&S®FSUP-B60 and R&S®FSUP-B61 options in the frequency range from 1 MHz to 26/50 GHz (R&S®FSUP26 and R&S®FSUP50).

Cross-correlation: Two identical receiver paths minimize the influence of the internal reference. The additional microwave frequency converter enables measurements up to 50 GHz.



Improvement of phase noise sensitivity by means of cross-correlation. Measurement of the phase noise of a signal source at 25.8 GHz without cross-correlation (green trace) and with cross-correlation, 100 (violet) and 1000 (yellow) averages.



Unique combination of phase noise tester and spectrum analyzer

The R&S®FSUP is not only a very sensitive phase noise tester, but in addition a high-end spectrum analyzer. This combination simplifies the test setup for the analysis of signal sources because it eliminates the typical requirement for an additional spectrum analyzer.

Measurement of phase noise using the spectrum analyzer method

Using the R&S®FSUP, phase noise can also be measured directly in the spectrum. Although this measurement is more time-consuming and less sensitive, it allows the measurement of significantly higher frequency offsets up to 10 GHz. The system noise can be subtracted after a reference signal measurement.

Typical spectrum measurements such as ACP or interference search

Apart from the normal functions of a spectrum analyzer, which are essential for measuring harmonics, the R&S®FSUP also offers enhanced measurement capabilities for VCO characterization such as the spurious emissions measurement function. Various sweep ranges can be defined in a list to specify where the analyzer should automatically search for interference. Up to 100000 measurement points are analyzed, and the result is displayed in a peak list. Unwanted interference located far from the carrier is quickly and easily detected.

Measuring adjacent channel power is another important function when characterizing signal sources. Here as well, the R&S®FSUP provides convenient measurement functions that make it possible to quickly determine the power of adjacent channels. Users can take advantage of pre-defined standard settings or define the channel width and spacing on their own with a high degree of flexibility. The unparalleled dynamic range of the R&S®FSUP sets new standards in the analysis of signal sources.

Measurement of noise figure using the R&S®FSUP

The R&S®FS-K30 application firmware provides the R&S®FSUP with features that are otherwise available only through special noise measurement systems. The following parameters can be measured at a specified frequency or in a selectable frequency range:

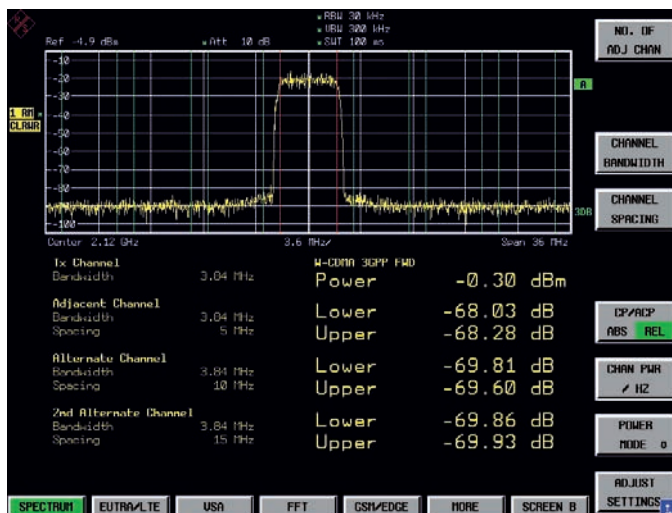
- ▮ Noise figure in dB
- ▮ Noise temperature in K
- ▮ Gain in dB

A phase noise measurement using the spectrum analyzer. The blue trace shows the measurement result up to an offset frequency of 1 GHz.

The inherent noise (green trace) is subtracted from the measured signal (yellow trace).



Measurement of the adjacent channel power of a 3GPP base station signal.



Analysis in the time domain

Transient response of oscillators

The R&S®FSUP can record the oscillator signal as a function of time and thus provide a wideband display of the settling or switching times for high-frequency sources. The following parameters can be analyzed in the time domain:

- Power
- Phase
- Amplitude
- Frequency

The resolution bandwidth, resolution filter and recording time can be varied as needed.

Transient response of a generator.

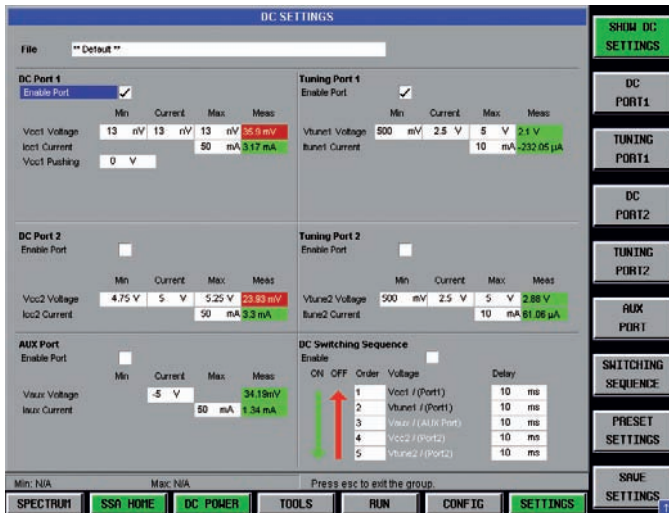


Characteristics at the push of a button

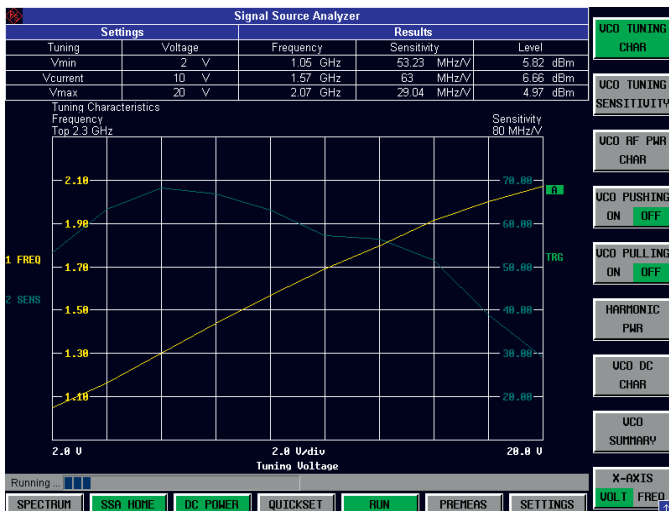
Specifications of the voltage sources

DC outputs	
Voltage	0 V to 12 V
Measurement uncertainty	<0.4%
Noise	10 nV/Hz at 10 kHz
Max. current	500 mA
Tuning outputs	
Voltage	-10 V to +28 V
Measurement uncertainty	<0.2%
Max. current	20 mA
Noise	1 nV/Hz at 10 kHz

Menu for setting the DC ports for signal source analysis and additional port for negative supply voltage.



VCO tuning characteristic: The result shows the settable frequency range and the tuning slope of the oscillator.



Low-noise voltage source for supply and tuning voltages

The R&S®FSUP has two separate, very-low-noise DC outputs for measuring the phase noise and for recording the characteristics. The supply and tuning voltages can be defined for each output. The voltages are entered by means of a straightforward menu. Depending on the application, the R&S®FSUP configures the values in line with the settings without falling below or exceeding the minimum and maximum values respectively. The user can define both the sequence in which the different voltages are switched on when the measurement starts and the port to be used for measuring the characteristics. The R&S®FSUP also has a negative voltage supply for special applications.

Complete characterization of oscillators

There are basically three types of measurements that can be carried out:

- ▮ Tuning characteristic: The tuning voltage is modified at a constant supply voltage
- ▮ DC dependencies: The supply voltage is modified at a constant tuning voltage
- ▮ The combination of both (pushing)

In addition, characteristic parameters can be measured not only for the fundamental, but also for the harmonics. For scaling the x-axis, the tuning voltage or the frequency is selectable. Settings such as the measurement procedure, trace display and order of harmonics are definable. In addition, all of the results can be summarized and displayed in a table.

Characteristics:

- ▮ Tuning range of the oscillator:
 - VCO tuning characteristic
- ▮ Other frequency dependencies:
 - VCO tuning sensitivity (tuning slope of oscillator)
 - VCO RF power characteristic (output power)
 - Harmonic power (power of upper harmonics)
- ▮ DC dependencies:
 - VCO DC characteristic (power and frequency of output signal)
 - DC dependencies in the tuning range
 - VCO pushing (tuning range at different input voltages)

The tuning voltage of the oscillator varies within the limits defined when the DC settings for the individual port were made. The result represents the settable frequency range and the tuning slope of the oscillator.

Analysis of digital and analog modulated signals

General vector signal analysis of digitally modulated signals

The R&S®FSQ-K70 vector signal analysis option expands the R&S®FSUP to support the universal demodulation and analysis of digital radio signals down to the bit stream level.

Supported wireless communications standards

- ▮ GSM and EDGE
- ▮ WCDMA-QPSK
- ▮ CDMA2000®-QPSK
- ▮ Bluetooth®
- ▮ TETRA
- ▮ PDC
- ▮ PHS
- ▮ DECT
- ▮ NADC

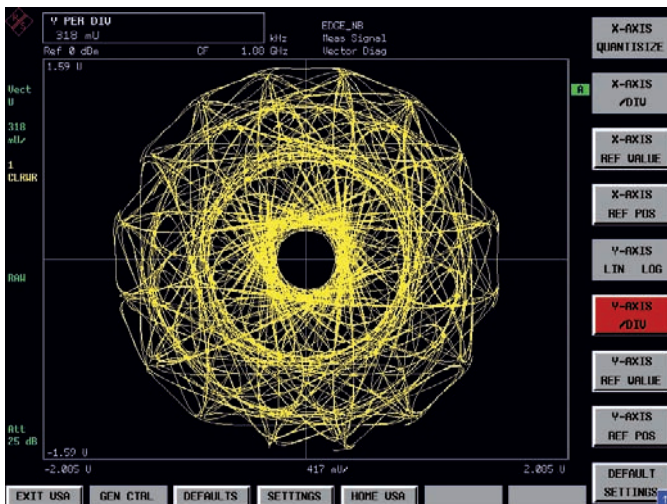
Supported digital modulation methods

- ▮ BPSK, QPSK, OQPSK
- ▮ $\pi/4$ -DQPSK
- ▮ 8PSK, D8PSK, $3\pi/8$ -8PSK
- ▮ (G)MSK
- ▮ 2, 4, (G)FSK
- ▮ 16, 32, 64, 128, 256 (D)QAM

Optimal display of the results

- ▮ Inphase and quadrature signals versus time
- ▮ Magnitude and phase versus time
- ▮ Eye diagram
- ▮ Vector diagram
- ▮ Constellation diagram
- ▮ Table with modulation errors
- ▮ Demodulated bit stream
- ▮ Statistical evaluation of modulation parameters
- ▮ Amplifier distortion measurements

Constellation diagram of an EDGE signal, analyzed with the R&S®FSQ-K70 vector signal analysis option.



Special analysis options for digital communications standards

From GSM ...

The R&S®FS-K5 GSM/EDGE application firmware provides the R&S®FSUP with all of the functions required to carry out RF and modulation measurements on GSM systems. The R&S®FS-K5 option comes with EDGE (generation 2.5).

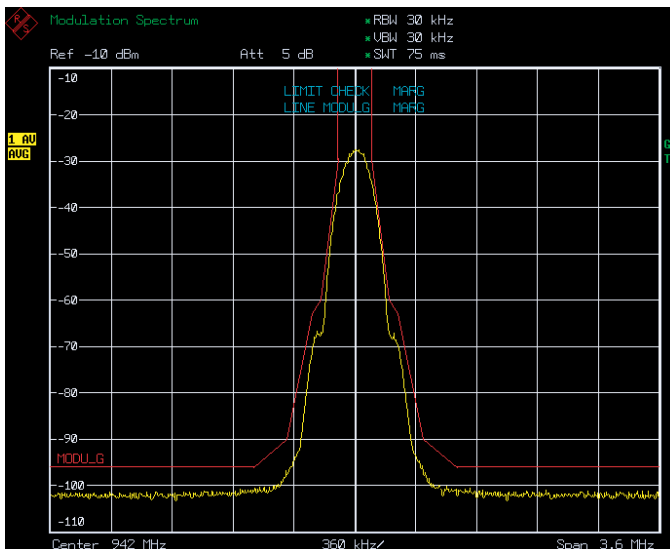
- ▮ Phase or frequency error for GSM
- ▮ Measurement of modulation quality for EDGE using EVM- and ETSI-compliant weighting filters
- ▮ OOS
- ▮ 95:th percentile
- ▮ Power versus time with synchronization to midamble
- ▮ Spectrum due to modulation
- ▮ Spectrum due to transients

... to UMTS

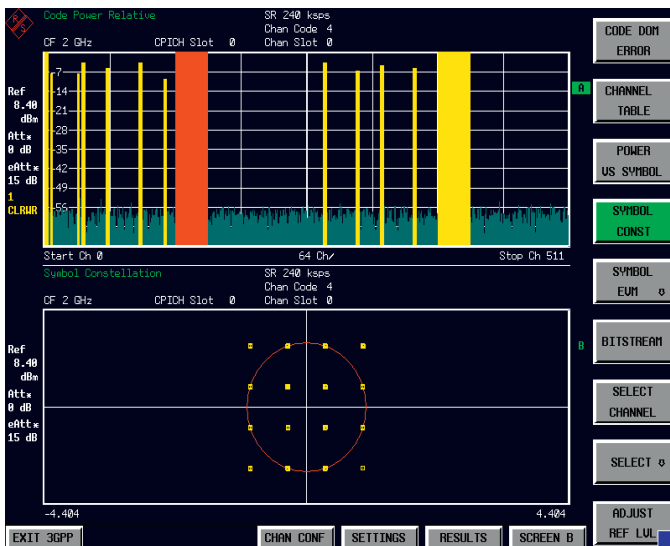
Modulation and code domain power measurements can be carried out on signals in line with the 3GPP standard using the R&S®FS-K7x application firmware.

- ▮ Additional functionalities for measuring 3GPP FDD and TDD LCR modes
- ▮ Fast measurement speed of 1 second/measurement for 3GPP base station signals
- ▮ Code domain, CPICH power and rho (CDMA2000®/3GPP2)
- ▮ EVM and PCDE
- ▮ Code domain power versus slot
- ▮ EVM/code channel
- ▮ HSPA
- ▮ Spectrum emission mask
- ▮ Constellation (symbol, composite)

Measuring the modulation spectrum of an EDGE burst.



WCDMA code domain power measurement by means of the R&S®FSUP and R&S®FS-K72/R&S®FS-K74 (HSDPA).

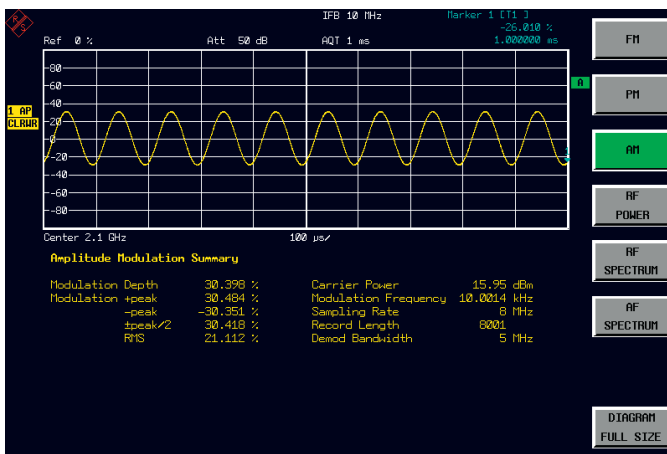


Analysis of analog modulated signals (AM/FM/φM)

The R&S®FS-K7 measurement demodulator for the R&S®FSUP enables the measurement of analog modulation parameters.

- Frequency modulation (FM)
- Amplitude modulation (AM)
- Phase modulation (φM)
- Table with numeric results:
 - Peak and RMS deviation, modulation frequency
 - Carrier offset, carrier power
 - Carrier power versus time
 - RF spectrum (FFT spectrum analysis)
 - AF spectrum with SINAD and THD values

Various filters (highpass, lowpass, deemphasis) are available that can be used to simulate real receive-signal structures, thus enabling accurate characterization of analog transmit and receive systems. The capability to perform Fourier analysis on the RF signal combines the advantages of a high-end spectrum analyzer with those of an FFT analyzer in a single box. Spectrum analysis can also be carried out by first recording the complete signal and then representing it in the frequency domain.



Demodulation of an AM-modulated signal: Power, modulation depth and frequency are displayed. An AF spectrum can also be calculated, which displays the SINAD and THD results.

Specifications in brief

Condensed data		
Operating modes	signal source analyzer	1 MHz to 8/26.5/50 GHz
	spectrum analyzer	20 Hz to 8/26.5/50 GHz
Signal source analyzer		
Phase noise measurement	with spectrum analyzer	10 MHz to 8/26.5/50 GHz
	with phase comparator	1 MHz to 8/26.5/50 GHz
	internal reference	1 MHz to 8/26.5/50 GHz
	external reference	1 MHz to 8 GHz
	with phase comparator and cross-correlation	1 MHz to 8/26.5/50 GHz
Transients measurement	min. frequency offset	10 mHz
	max. frequency offset	30 MHz
Residual noise	with phase comparator	1 MHz to 8 GHz ¹⁾
AM noise		see diode datasheet

¹⁾ If the internal phase detector is used.

Sensitivity

Sensitivity with internal reference and internal phase detector.

Input level >+10 dBm, spurious and harmonics <-30 dBc, mode "averaged", +20°C to +30°C. LNA gain 40 dB, loop bandwidth $\leq 10 \times$ frequency offset, max. 1 kHz. With the R&S®FSUP-B60 low phase noise option and the R&S®FSUP-B61 correlation extension option.

Typical values

Frequency offset	Input frequency, values in dBc (1 Hz) R&S®FSUP8/26/50						R&S®FSUP26/50		R&S®FSUP50
	5 MHz	10 MHz	100 MHz	1 GHz	3 GHz	7 GHz	10 GHz	20 GHz	40 GHz
1 Hz	-114	-116	-87	-75	-62	-55	-52	-48	-42
10 Hz	-136	-135	-110	-91	-87	-80	-77	-71	-65
100 Hz	-143	-146	-134	-115	-106	-97	-95	-89	-83
1 kHz	-157	-161	-160	-134	-123	-118	-116	-112	-106
10 kHz	-165	-168	-168	-143	-131	-129	-126	-120	-114
100 kHz	-171	-170	-176	-158	-139	-140	-138	-132	-126
1 MHz	-	-175	-177	-165	-160	-155	-150	-146	-140
10 MHz	-	-	-179	-172	-170	-170	-167	-161	-155
30 MHz	-	-	-179	-172	-170	-170	-170	-165	-159

VCO parameter characterization

Measurement parameters	VCO tuning characteristic, VCO tuning slope, power, pushing ON/OFF, harmonics measurement, VCO DC characteristic, summary	
Frequency range	R&S®FSUP8	10 MHz to 8 GHz
	R&S®FSUP26	10 MHz to 26.5 GHz
	R&S®FSUP50	10 MHz to 50 GHz
Power supplies	tuning ports	2
	DC ports	2
	additional ports	1

Ordering information

Designation	Type	Order No.
Signal Source Analyzer, 20 Hz to 8 GHz	R&S®FSUP8	1166.3505.09
Signal Source Analyzer, 20 Hz to 26.5 GHz	R&S®FSUP26	1166.3505.27
Signal Source Analyzer 20 Hz to 50 GHz	R&S®FSUP50	1166.3505.51

Accessories supplied:
 RF cable, 1 m (1130.1725.00)
 R&S®FSUP26: test port adapter with 3.5 mm female connector (1021.0512.00) and N female connector (1021.0535.00)
 R&S®FSUP50: test port adapter with 2.4 mm female connector (1088.1627.02) and N female connector (1036.4777.00)

Options

Designation	Type	Order No.	Retrofit	Remarks
Options				
Low-Aging OXCO	R&S®FSU-B4	1144.9000.02	yes	
External Generator Control	R&S®FSP-B10	1129.7246.03	yes	
Removable Hard Disk	R&S®FSUP-B18	1303.0400.05	no	
Second Hard Disk for R&S®FSUP-B18	R&S®FSUP-B19	1303.0600.05		requires R&S®FSUP-B18
LO/IF Ports for External Mixers	R&S®FSUP-B21	1157.1090.04	no	for R&S®FSUP26 and R&S®FSUP50
20 dB Preamplifier, 3.6 GHz to 26.5 GHz, for R&S®FSU26	R&S®FSU-B23	1157.0907.02	no	for R&S®FSUP26, requires R&S®FSU-B25
Electronic Attenuator, 0 dB to 30 dB, and 20 dB Preamplifier (3.6 GHz)	R&S®FSU-B25	1144.9298.02	yes	
Trigger Port	R&S®FSP-B28	1162.9915.02	yes	
Low Phase Noise	R&S®FSUP-B60	1169.5544.03	yes	
Correlation Extension for R&S®FSUP26 (without R&S®FSU-B23)	R&S®FSUP-B61	1305.2500.26	no	for R&S®FSUP26, not for R&S®FSUP50, requires R&S®FSUP-B60
Correlation Extension for R&S®FSUP26 (with R&S®FSU-B23)	R&S®FSUP-B61	1305.2500.23	no	for R&S®FSUP26, not for R&S®FSUP50, requires R&S®FSUP-B60, R&S®FSU-B25 and R&S®FSU-B23
Correlation Extension for R&S®FSUP50	R&S®FSUP-B61	1305.2500.50	no	for R&S®FSUP50, not for R&S®FSUP26, requires R&S®FSUP-B60
Firmware/software				
GSM/EDGE Application Firmware	R&S®FS-K5	1141.1496.02		
Bluetooth® Application Firmware	R&S®FS-K8	1157.2568.02		
Power Sensor Measurements	R&S®FS-K9	1157.3006.02		
Application Firmware for Noise Figure and Gain Measurements	R&S®FS-K30	1300.6508.02		preamplifier recommended (e.g. R&S®FSU-B25)
Vector Signal Analysis	R&S®FSQ-K70	1161.8083.02		
3GPP BTS/Node B FDD Application Firmware	R&S®FS-K72	1154.7000.02		
3GPP UE FDD Application Firmware (including HSUPA)	R&S®FS-K73	1154.7252.02		
3GPP HSDPA BTS Application Firmware	R&S®FS-K74	1300.7156.02		requires R&S®FS-K72
3GPP HSPA+ BTS Application Firmware	R&S®FS-K74+	1309.9180.02		requires R&S®FS-K74
3GPP TD-SCDMA BTS Application Firmware	R&S®FS-K76	1300.7291.02		
3GPP TD-SCDMA UE Application Firmware	R&S®FS-K77	1300.8100.02		
CDMA2000® IS-95 (cdmaOne)/1xEV-DV BTS Application Firmware	R&S®FS-K82	1157.2316.02		
CDMA2000® 1xEV-DV MS Application Firmware	R&S®FS-K83	1157.2416.02		
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